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Report summarizes effort expended under subject contract to install Rockwell's Configuration Development System on the NAVAIR VAX 11-780. This effort provides NAVAIR with capabilities for aircraft conceptual design and initial analysis for drag, weight, balance, aerodynamic center, etc., using an interactive graphics terminal.

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## EXECUTIVE SUMMARY

A fixed price level of effort was performed to install Rockwell's Configuration Development System (CDS) at the Naval Air Systems Command (NAVAIR) facility in Washington, D.C. (Crystal City). Installation of CDS permits NAVAIR the capability to conceptually design aircraft concepts on an interactive graphics terminal and also perform conceptual analysis and concept iteration.

Under the contract, the CDS system was converted to run on a VAX 11-780 computer. Program modifications were implemented to allow a greater degree of device-independence, especially for terminal input/output. Also, the CDS program was tested and debugged, the command interpreter was improved, and some additional capabilities were developed. The manual was rewritten including the addition of training materials for classroom and hands-on instruction. Finally, the system was installed and users were trained.

# CDS/NAVAIR FINAL REPORT

## 1. INTRODUCTION

Rockwell's Configuration Development System (CDS) is a unique system of computer programs developed at the North American Aircraft Division (NAAD) which provide conceptual aircraft geometry design capabilities beyond any other computer-aided conceptual design systems currently available. Complete three-dimensional (3-D) geometry descriptions of an aircraft configuration, including external mold lines and internal components, may be designed interactively on a computer graphics terminal.

CDS was conceived in 1976 and initially coded in early 1977. Since then many evolutionary improvements have been added to CDS because of experience gained by designing aircraft configurations with CDS. CDS has been used at NAAD for many advanced configuration studies. Mold lines lofted on CDS have been used to build wind tunnel models, radar cross section models, and full-scale mockups.

The CDS/NAVAIR system provides NAVAIR with 3-D geometry design and modeling capability. Limited configuration analysis is also available within the CDS/NAVAIR system. Geometry developed on the CDS/NAVAIR system can be made available to external computer programs for analysis or evaluation. Configurations developed on CDS can be displayed in side, top, rear, and three-view. Orthographic and perspective views can also be made at any orientation or viewing distance. Cross sections can be cut as station, waterline, buttock-line, or canted cuts, in any orientation. Geometry data are also available for use in external analysis, plotting, and detailed design. Special development and analysis functions are available within CDS to aid in the configuration development process. Initial tail sizing, trapazoidal wing generation, simple fuselage generation, first-order mission sizing, skin friction and wave drag estimates, preliminary weight and balance, volume and surface area distributions, flat-plate aerodynamic balance, and landing-gear sizing are included as CDS functions.

The designer directs CDS by typing simple English commands and using graphical input devices (e.g., screen crosshairs or magnetic tablet). Configurations may be created and stored on disk files for later use or external evaluation. Components of the configuration may be scaled, translated, and rotated in three dimensions. New components representing almost any physical part of an aircraft (fuselage, wing, engine, ejection seat, longeron, etc), may be interactively developed and stored on disk for future use, if desired. Components are defined by either stacked, parallel cross sections or as multiple-patch biquartic surfaces.

CDS is proprietary property of Rockwell, not intended for general release. Source code was provided for all operating system-dependent or input/output (I/O)-related routines. This allows for easy two-way interfacing with other programs and also allows for changes in the operating system. Source code was also provided for some analysis programs. All geometry manipulation, design, and quartic lofting routines were provided only as object code.

Table I identifies CDS/NAVAIR system segments and indicates whether source code has been provided.

## II. DESCRIPTION OF WORK ACCOMPLISHED

All tasks in the statement of work have been accomplished. Originally, conversion to the CDC 6600 was attempted, and is described below. Due to an undetermined inconsistency in the CDC systems software, CDC implementation was not possible, so conversion to the VAX was accomplished onsite.

### TASK I - CONVERSION PREPARATION

The lead programmer identified what specific parts of the CDS software had to be changed to allow it to operate on a CDC computer. This task was necessary to identify possible problems that may have been encountered during conversion because of program structure. Necessary organizational changes to the CDS system were identified and implemented during the verification task.

### TASK II - VERIFICATION DEFINITION

Existing CDS software was verified to be as free of errors as is practically possible. Since CDS is being continuously updated and modified, a version was frozen and verified before conversion was attempted.

The major CDS errors uncovered and fixed during this task were in the statistical weight estimating routines and in the volumetric centroid calculation. Also, new capabilities were added to allow creation of new components by taking section cuts of existing components.

### TASK III - UNIVAC VERSION VERIFICATION

The CDS software on the UNIVAC computer was modified and verified in accordance with the verification definition provided by Task II. The result of this task was a frozen verified version of CDS residing on the UNIVAC computer, denoted as CDS Version Five.

Table I

CDS/NAVAIR SYSTEM SEGMENTS

| Name | | Source Provided |
|---|---|---|
| MAIN | Main overlay control, command interpreter, and executive monitor | Yes |
| TKLB | Tektronix terminal I/O routines | Yes |
| FILE | Data base handling routines | Yes |
| EDIT | Component geometry manipulation, design, and lofting routines | No |
| PMOD | Section geometry manipulation, design, and lofting | No |
| QUAR | Quartic parametric curve fitting, lofting, and generation routines | No |
| DISP | 3-D display generation and plotting routines | Yes |
| VWD | External interface program | Yes |
| CSP | Cross section cutting routines | No |
| SFD | Skin friction drag calculation and volume and area calculation | Yes |
| WAVE | Wave drag calculation | Yes |
| MISN | First-order mission sizing routine | Yes |
| FUDP | Aerodynamic center and balance calculation | Yes |
| ADDA | Additional information and CG calculation program | Yes |
| INIT | Trapazoidal surface and initial fuselage generation routines | Yes |
| COST | Cost-estimating program (based on modified Rand 31 aircraft, cost models) | Yes |
| TIRE | Initial statistical tire and strut sizing program | Yes |
| TAIL | Tail size calculation routines (based on tail volume coefficients) | Yes |
| CONV | Routines for conversion to and from quartic surface representation | No |

TASK IV - MANUAL REWRITE AND GENERAL DOCUMENTATION

The existing CDS users manual was updated to provide a description of all commands, operations, and error messages. The manual describes CDS design methods and contains tutorial examples. An index is provided for quick location of specific information. Also, appendices contain the training lecture viewgraphs, the analysis equation descriptions, and a Data Base and related subroutine description.

TASK V - UNIVAC TO CDC CONVERSION

All routines within CDS that are concerned with disk I/O were modified to CDC-type random access disk I/O. Methods of file creation, deletion, and updating were modified to conform with CDC FORTRAN I/O and the CDC NOS/BE1 operating system.

Terminal I/O routines were modified to conform with CDC FORTRAN and the NOS/BE1 operating system.

Character manipulation routines were modified to accommodate the 6-bit byte, 60-bit word architecture of the CDC machine. Existing CDS software is written for the 8-bit byte, 16-bit word Univac machine.

Operating system-dependent routines were modified to conform with the requirements of the CDC NOS/BE1 operating system. The majority of this modification was concerned with overlay control and common blocks.

TASK VI - TRAINING MATERIAL PREPARATION

Material necessary for the training of NAVAIR personnel was developed during this task. Self-study tutorial examples were developed and added to the users manual. These examples allow a new user to learn CDS design methods by following a step-by-step procedure while using the computer graphics terminal.

Material necessary for classroom instruction was also developed under this task. This material consists of visual aids to be used during the training of NAVAIR personnel.

TASK VII - CDC VERSION VERIFICATION

Converted source code was transmitted to the Rockwell CDC Cyber 176 mainframe using the RJE facilities of the Sperry Univac V76 computer. After successful compilation and loading, CDS was executed on the Cyber 176 using a Tektronix 4014-1 graphics terminal connected through a 1,200-baud communication line.

CDS operation was then verified using the criteria defined in Task II. The program was checked out by an experienced CDS user.

TASK VIII - INSTALLATION AND VERIFICATION

Verified CDC object code was then output to magnetic tape using the CDC Cyber 176 mainframe. Job control language necessary for the compilation, linkage, loading, and execution was also output to magnetic tape. Source code for all operating system-dependent, I/O-related and other programs were output to magnetic tape as defined in Table I.

The magnetic tape was then carried to NAVAIR where the CDS software was installed by Rockwell personnel with the aid of NAVAIR systems programmers. However, some systems software inconsistency prevented successful operation, and could not be resolved at this time. Therefore, CDS was installed on the VAX 11-780 as provided for in the contract.

TASK IX - TRAIN NAVAIR PERSONNEL

Rockwell personnel then trained NAVAIR personnel in the use of CDS in classroom lectures and supervised on-line training sessions.

## III. RESULTS

The CDS/NAVAIR System has been installed and is ready for production use at NAVAIR. Users have been trained, and will further improve in their abilities on the system with more experience.

## IV. CONCLUSIONS AND RECOMMENDATIONS

NAVAIR now has a functioning computerized aircraft conceptual design capability. To make maximum use of this capability, NAVAIR should interface it with all of its aircraft analysis programs which use geometry as an input. Sufficient information and source code have been provided to permit NAVAIR programmers to do this, or it could be done by Rockwell personnel in follow-on contracts. Also, NAVAIR should interface CDS/NAVAIR with some form of high-quality line plotter such as the CALCOMP plotter used by Rockwell's CDS.

In addition, Rockwell is continuously developing improvements to CDS. Some capabilities under study for implementation include detailed RCS analysis, improved quartic design flexibility, and a true "on-line" level 1 performance analysis and sizing capability. These could also be candidates for follow-on efforts.


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